RYBAKOV, B.A.

"Le calendrier magico agraire des anciens Polonais."

Report submitted to the 6th Intl. Cong. of the Intl. Union of Prehistoric and Prohistoric Sciences, Rome, Italy 29 Aug - 3 Sep 1962

1. RYBAKOV, B. A.

2. USSR (600)

4. Geology and Geography

7. Polovetsian Steppe, K. V. Kudryashov. (Outlines of Historial Geography, Records of the All-Union Geographical Society, New Series, Vol II, Moscow, Geography Press, 1948) Reviewed by B. A. Rybakov, Sov. Kniga, No. 11, 1949.

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21377 RYBAKOV, B. A. Dreuneyshaya Russkaya karta nachala XVI- v.
I yeye vliyanie na yevropeyskuyu kartografiya XVI-XVIII vv
(Tezisy Dokiada). Trudy vtorogo usesoyuz. Geogr. S'ezda. T.III
M., 1949, s. 281-82

SO: Letopis' Zhurnal'nykh Statey, No. 29, Moskva, 1949.

RYBAKOV, P. A.

Poland -Descripton and Travel

In the region of the Vistula. Vokrug sveta 91 No.4, 1952.

Monthly List of Russian Accessions, Library of Congress, July 1952, UNCLASSIFIED

RYBAKOV, B.I.

Sinian sediments of the Udzha uplift. Trudy NIIGA no.125:31-45 '61. (MIRA 16:7)

(Udzha Valley--Geology, Stratigraphic)

RYBAKOV, B.I.

Municipal postal centers. Vest. sviazi 17 no.3:19-20 Mr '57.
(MLRA 10:4)

1. Nachal'nik Odesskogo otdeleniya perevozki pochty.
(Postal service)

RYBAKOV, B.M.

KARPECHENKO, P.S., kand.tekhn. nauk; RYBAKOV, B.M., kand. tekh. nauk; SYCHEV, V.I., inzh.

Torch cutting of plain and reinforced concrete. Bet. i zhel.-bet. no.3:116-117 Mr '58. (MIRA 11:3)
(Oxyacetylene welding and cutting)

NIKOLAYEVA-FEDOROVICH, N.V.; IKONOPISOV, S.M.; RYBAKOV, B.N.

Electroreduction of PtF_6^{2-} on a dropping mercury electrode.
Zhur. fiz. khim. 38 no.5:1347-1349 My '64.

(MIRA 18:12)

1. Moskovskiy gosudarstvennyy universitet imeni Lomonosova.
Submitted July 10, 1963.

RYBAKOV, B.N.; NIKOLAYEVA-FEDOROVICH, N.V.; ZHUTAYEVA, G.V.

Experimental proof of the effect of ohmic potential drop in the bulk of solution on the limiting current of the electro-reduction of anions. Zhur. fiz. khim. 38 no.3:782-783 Mr '64. (MIRA 17:7)

1. Moskovskiy gosudarstvennyy universitet imeni M.V. Lomonosova.

RYBAKOV, B.N.; NIKOLAYEVA-FEDOROVICH, N.V.; ZHUTAYEVA, G.V.

Reduction kinetics of the S O anion on a rotati g lead electrode. Zhur. fiz. khim. 38 no.2:500-503 F '64. (MIRA 17:8)

1. Moskovskiy gosudarstvennyy universitet imeni Lomonosova.

31960
S/081/61/000/023/010/061
B108/B147

54700

AUTHORS: Kuznetsov, V. V., Rybakov, B. N.

TITLE: Effect of hydrogen-absorption catalysts on the hydrogen overvoltage on nickel in sulfuric acid

PERIODICAL: Referativnyy zhurnal. Khimiya, no. 23, 1961, 70, abstract 23B530 ("Izv. Yestestvennonauchn. un-ta pri Permsk. un-te", v. 14, no. 4, 1960, 13 - 18)

TEXT: The effectsof additions of As_2O_3 (3.3 - 132 mg/liter) and SeO_2 (5 - 125 mg/liter) on the hydrogen overvoltage η at $i = 6 \cdot 10^{-5} - 1 \cdot 10^{-3}$ a/cm^2 and on the stationary potential φ_s of a Ni electrode in an 0.1 N H_2SO_4 have been studied. The sample of spectroscopically pure Ni sheets was annealed for 30 min in vacuo at 900°C, then polished, degreased in a 2 N NaOH at 65 - 70°C, and rinsed with distilled water. As_2O_3 addition shifts φ_s toward the positive side and increases η. The curves (η(logi))

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31960

S/081/61/000/023/010/061

Effect of hydrogen-absorption catalysts on... B108/B147

exhibit two domains; the slope is steeper at low values of i than at high ones. SeO_2 affects φ_s and η in the same way as As_2O_3, but the effects are not quite as strong. The results are explained by a deceleration of the recombination of H (adsorption) owing to molecular precipitation of As and Se on the electrode. [Abstracter's note: Complete translation.]

Card 2/2

RYBAKOV, B.N.; NIKOLAYEVA-FEDOROVICH, N.V.

Reduction of the MnO_4^- on a mercury-dropping electrode. Dokl. AN SSSR 151 no.5:1135-1138 Ag '63. (MIRA 16:9)

1. Moskovskiy gosudarstvennyy universitet im. M.V.Lomonosova. Predstavleno akademikom A.N.Frumkinym.
(Permanganates) (Reduction, Electrolytic)
(Electrodes, Dropping mercury)

CA

29

Rapid determination of fat in leather. N. P. Kostin, B. N. Rybakov and P. K. Isaev. *Kozhevenno-Obuvnaya Prom. S. S. S. R.* **12**, No. 4, 56(1939); *Chem. Zentr.* 1939, II, 2501.—The method proposed by Wislicenus in 1920 (cf. *C. A.* **15**, 380) for the analysis of coal, wood, etc., is recommended for the detn. of fat in leather. The sample is placed in a flask equipped with a reflux condenser through which a thread is passed only at the beginning of the boiling of the ether. The thread is removed after the end of the boiling and is rinsed with the condensate passing through the condenser. The "boiling" time is limited to 10 min. and the "rinsing" time to 15 min. The results agree satisfactorily with those of the Soxhlet method.

A. A. Boehtlingk

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

BRILL', O.D.; PANKRATOV, V.M.; RUDAKOV, V.P.; RYBAKOV, B.V.

Cross sections of the reactions T(d, n)He^4 and D(d, n)He^3 in the 3 - 19 Mev. deuteron energy range. Atom. energ. 16 no.2:141-143 F '64. (MIRA 17:3)

Rybakov, B.V.

Penetration of protons in medium and heavy elements. B. V. Rybakov. *Zhur. Eksptl. i Teoret. Fiz.* 28, 651–4 (1955).—Al equivs. of proton penetration for Fe, Cu, Mo, Cd, Sn, Ta, and Pb were obtained with proton beams of 7.3 ± 0.07 m.e.v. obtained from a cyclotron. Al filters of various thickness were placed in front of the samples until the half-absorption point was reached. The results are summarized in a curve showing the thickness of the foil in mg./sq. cm. for half-absorption *vs.* energy (1–7 m.e.v.) for the above elements, and in a group of curves showing the thickness *vs.* the at. no. for 1–7-m.e.v. protons. S. Pakswer 62

APPROVED FOR RELEASE: 07/19/2001 CIA-RDP86-00513R001446330003-7"

CARD 1 / 2 PA - 1606

SUBJECT USSR / PHYSICS

AUTHOR BOGDANOV,G.F., KURASHOV,A.A., RYBAKOV,B.V., SIDOROV,V.A.

TITLE The Measurements of Fast Neutron Spectra by Time-of-Flight Methods.

PERIODICAL Atomnaja Energija, 1, fasc. 1, 66-82 (1956)
Issued: 3 / 1956

Whereas the usual methods for measuring fast neutrons can be used up to 2 - 3 MeV at the most, time of flight measurements for slow neutrons do not go beyond 1 keV.
Modern scintillation counters have a resolving power in time of 10^{-9} sec and make it possible, by using a pulsating neutron source which furnishes impulses of 5.10^{-9} sec in the case of a period of 112.10^{-9} sec, to measure up to some 10 MeV.
The scintillation counter was connected with a coincidence device which, besides, received impulses from the excitation frequency of the cyclotron, which can be delayed ad.lib., so that every time of flight could be measured.
After some constructional details there follow data concerning the time resolving capacity which is equal to that of the coincidence device and the duration of the primary impulse. Calibration was carried out by the bombardment of a T Zr sample with protons. The calibration curve shows two maxima at the end and at the beginning of the energy domain; the former originates from radiation caused by the reaction of protons with Zr, the latter was caused by the reaction

T (p,n) He^3. Energy resolving power is connected with the length of flight and with energy as follows: $t_{(m\mu\,sec)} = \frac{72L(M)}{\sqrt{E(MeV)}}$. If the period of the impulse T is (112 msec) and if the response threshold of the counter is V, the condition for a maximum L can be written down as follows:

$72L_{max}V^{-1/2} = T + 72L_{max}E^{-1/2}$. This means that the slowest neutrons must arrive before the slowest of the next momentum. Maximum resolving power of the spectrometer at energies of from 3 - 15 MeV is 10-24%. An increase of the response threshold reduces this value. The degree of efficiency of the scintillation counter attains several % at 2 - 20 MeV. For the determination of the spectral sensitivity calibration measurements were taken and a curve was given.

The main difficulties of this work were connected with the instability of the phase of the cyclotron.

INSTITUTION:

shell model, BRUECKNER'S theory (BETHE), neutrons and nuclear structure, "repulsion" of nuclear levels, etc.
II) Capture Reactions and Photonuclear Reactions: The following reports were, among others, made: Reactions of the type (x,γ), where x denotes neutron, proton, or α-particle; rotation levels of light nuclei, absorption mechanism of electromagnetic radiation by the nucleus, theory of photonuclear reactions, radiation capture of protons, angular- and energy distribution of photoneutrons, etc.
III) Stripping- and "Capture" Reactions: The reactions (d,p) and (d,n) at a deuteron energy of up to 20 MeV, neutron spectra on the occasion of the bombardment of light nuclei by 14-MeV deuterons, relative probabilities of stripping processes and of the creation of a composed nucleus, theory of direct interaction, interaction of fast deuterons with nuclei, the present stage of (n,p) and (p,p) scattering (SEGRÉ), elastic scattering of 188 MeV electrons by various nuclei, etc.
IV) Reactions under the Effect of Heavy Ions and Fission Processes: Radiochemical investigations of reactions with accelerated C- and N-ions, theoretical work carried out at LOS ALAMOS on nuclear fission, excitation curves of the symmetric and asymmetric photofission of U^{238} and Th^{232}, energy dependence of gap width, etc.

INSTITUTION:

RYBAKOV, B.V.

Neutron spectra from the bombarding of tritium and deuterium with deuterons of energy 14 m.e.v. G. F. Bogdanov, N. A. Vlasov, S. P. Kalinin, B. V. Rybakov, and V. A. Sidorov. *Soviet Phys., JETP* 3, 793-5 (1956) (Engl. translation).—See *C.A.* 50, 14390*b*. B. M. R.

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4129

SPECTRA OF NEUTRONS PRODUCED BY BOMBARDING LIGHT NUCLEI WITH 14 MEV DEUTERONS. G. F. Bogdanov, N. A. Vlasov, S. P. Kalinin, B. V. Rybakov and V. A. Sidorov. Soviet Phys. JETP 3, 793-5(1956) Dec.

RYBAKOV, B.V.

Category : USSR/Radiophysics - Application of Radiophysical Methods I-12

Abs Jour : Ref Zhur - Fizika, No 2, 1957, No 4694

Author : Rybakov, B.V.

Title : Construction of Apparatus for the Comparison of Code Pulses with Protection Against False Operations, and Investigation of the Operation of such Apparatus.

Orig Pub : Radiotekhnika, 1956, 11, No 7, 26-38

Abstract : Description of the principle for the construction of electronic apparatus for the comparison of code pulses, based on a newly-developed anti-coincidence circuit with protection against false operations. The apparatus makes it possible to compare code pulses arriving from the output of various kinds of memory units or coders. The analysis of the operation of the apparatus makes it possible to calculate the basic parameters of the circuit required to meet specified operating conditions.

Card : 1/1

RYBAKOV, B.V.

USSR/Nuclear Physics - Structure and Properties of Nuclei C-4

Abst Journal : **Referat Zhur - Fizika, No 12, 1956, 33990**

Author : Bogdanov, G F., Vlasov, N. A., Kalinin, S. P., Rybakov, B. V.
Sidorov, V. A.

Institution: None

Title: Spectra of Neutrons Bombarded with T and D Deuterons with Energies of 14 Mev

Original Periodical: Zh. eksperim. i teor. fiziki, 1956, 30, No 1, 185-187

To check the existing experimental data on the existence of an excited state of approximately 2 Mev in the He^4 nucleus, spectra were studied of neutrons produced by the $T(d,n)\,He^4$ and $D(d,n)\,He^3$ reactions, with the neutrons escaping at an angle of 0^o relative to the beam of the deuterons. The beam of the 14 Mev deuterons was focused with the aid of a magnetic prism at a distance of 12 m from the cyclotron, where a thin tritium-zirconium or a gas deuterium target was placed. The energy of the neutrons

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Abst Journal : Referat Zhur - Fizika, No 12, 1956, 33990

was measured from the time it took them to cover the distance from the target to the counter, the latter being a photomultiplier with a solid solution of terphenyl in polystyrol acting as a phosphor. The neutron source was operating under pulse conditions based on the natural modulation of the cyclotron beam. The pulses from the counter went to a germanium-diode coincidence circuit. Pulses, synchronized with the accelerating voltage of the cyclotron were applied to the second leg of the coincidence circuit. The time resolution of this spectrometer (width of gamma line at half the altitude) amounted to 7 $m\mu$ seconds.

The spectrum of the neutrons from the $T(d,n) He^4$ and $D(d,n)He^3$ reactions displayed not only the maxima corresponding to the formation of the He^4 and He^3 nuclei in their fundamental states but also wide groups of slower neutrons with an average of energy of 8 Mev. For the T + d reaction this energy corresponds to an excitation energy of finite nucleus of approximately 22 Mev. However, the similarity of the spectra in

USSR/Nuclear Physics - Structure and Properties of Nuclei C-4

Abst Journal : Referat Zhur - Fizika, No 12, 1956, 33990

the case of both reactions is indication in favor of the assumption that the second groups of neutrons are formed faster by a break-up of the deuteron than by the usual reaction with a formation of a finite nucleus He^4 and He^3 in excited state. Notice is taken of the large value of the cross section for the formation of the neutrons of the second groups. This amounts to 300 millibarns/steradian for the case of the T + d reaction, and 100 millibarns/steradian for the case of the D + d reaction.

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SUBJECT USSR / PHYSICS CARD 1 / 2 PA - 1394

AUTHOR BOGDANOV, G.F., VLASOV, N.A., KALININ, S.P., RYBAKOV, B.V., SIDOROV, V.A.

TITLE The Spectra of Neutrons produced on the occasion of the Bombardment of Light Nuclei by 14 MeV Deuterons.

PERIODICAL Žurn.eksp.i teor.fis, 30, fasc.5, 981-983 (1956)
Issued: 8 / 1956 reviewed: 10 / 1956

In order to become fully acquainted with the production mechanism of neutrons on the occasion of the bombardment of tritium and deuterium by 14 MeV deuterons previous measurements (G.F.BOGDANOV et al, Zurn.eksp.i teor.fis, 30, 185 (1956)) were continued with targets of other light elements (gaseous elements of H, He^3, He^4 as well as solid elements of Li,Be,B,C and Cu). The neutrons were analyzed on the basis of the time of passage through the stretch between target and counter (2,85 m). The construction of the gaseous and liquid targets is described. The data obtained by averaging over a number of series of measurements are shown in diagrams. The acuity of the device makes it possible to discover individual levels of the nucleus created by reaction only on the occasion of the bombardment of the isotopes of hydrogen and helium; in all other cases spectra must be continuous. The spectrum of the neutrons and their production cross section do not change steadily with the number of the nucleons in the nucleus.
In the case of a high positive thermal effect Q of the reaction the upper limits of the spectra are higher than the maximum energy of the neutron which is produced on the occasion of the fission of the deuteron without modification of the

bombarded nucleus. Consequently, the state of the nucleus produced by the reaction exercises essential influence upon the neutron spectrum under investigation. A comparison between the production cross sections and spectra of neutrons corresponding to the reactions T+d and He^3+d confirms the existence of an excited state of He^4 with the excitation energy ~22 MeV, and is indicative of the fact that no similar state exists in the case of the Li^4 nucleus. H^4 and Li^4 probably do not exist in a state that is similar to the excited state of He^4. This confirms the assumption that the isotopic spin of the excited He^4-state with 22 MeV is equal to zero. Next, the neutron spectrum produced on the occasion of the bombardment of He^4 is discussed in short. On the occasion of this (d,n)-reaction an Li^5 nucleus is produced, for which, apart from the ground state, a second state with an energy surpassing that of the ground state by 2,5 MeV was hitherto assumed to exist. However, in the neutron spectrum of the reaction He^4+d no excited state of Li^5 could be found.

Furthermore, the production cross sections of the neutrons emitted in the direction of 0^o towards the deuteron bundle were estimated for various targets. In the case of all investigated light elements with the exception of tritium this cross section is ~50 mb/sterad per nucleon of the nucleus, which means that it is approximately proportional to the number of nucleons A. On the occasion of transition to heavy nuclei the cross section decreases and in the case of Cu, for instance, it is 200 mb/sterad.

INSTITUTION:

RYBAKOV, B.V., BOGDANOV, G.F., KALININ, S.P., SIDOROV, V.A., VLASOV, N.A.

"The (p.n.) Reaction on Lithium and the Ground State of Be^{6}."

paper submitted at the All-Union Conf. on Nuclear Reactions in Medium and Low Energy Physics, Moscow, 19-27 November 1957.

RYBAKOV, B.V., ARTEMOV, K.P., BOGDANOV, G.F., KALININ, S.P., SIDOROV, V.A.
VLASOV, V.A.

"Spectra of Neutrons and Protons from ($He^4 + d$) Reaction and Energy Levels of Li^5 and He^5."

paper submitted at the All-Union Conf. on Nuclear Reactions in Medium and Low Energy Physics, Moscow, 19-27 November 1957.

RIBAKOV, B. V., KALININ, SP, VLASOV, N. A., BOGDANOV, G. F., and DISOROV, V. A.

"Spectra of the Fast Neutrons from (p,n) Reactions Are Measured on the 1.5 Meter Cyclotron by the Time-of-Flight Method," a paper presented at the International Conference on the Neutron Interactions with the Nucleus, New York City, 9-13, Sep57.

Abstract available in C-3,800,344

RYBAKOV, B. V., VLASOV, N. A., BOGDANOV, G. F., [illegible]

"Time - of-Flight Analysis of the Reaction of 18 Mev Deuterons with Light Nuclei," a paper submitted at the International Conference on the Neutron Interactions wtih the Nucleus, New York City, 9-13 Sep 57

Abstract available in C-3,800,344

RYBAKOV, B.V.

89-9-2/32

AUTHOR BOGDANOV, G.F., VLASOV, N.A., KALININ, S.P., RYBAKOV, B.V., SIDOROV, V.A.

TITLE The Li(p,n)Be reaction and the Fundamental Structure of the Be^6 Nucleus.
(Reaktsiya(p,n) na litii i osnovnoye sostoyaniye yadra Be^6)

PERIODICAL Atomnaya Energiya, 1957, Vol 3, Nr 9, pp 204 - 210 (U.S.S.R.)

ABSTRACT
By means of the time of flight method the neutron spectrum emitted by the reactions Li^6+p and Li^7+p = 9 MeV is measured. Further, the redistribution of neutrons and the reaction cross sections were measured. The results are

1) $Li^6(p,n)Be^6$
a) $Q_o = -5,2 \pm 0,2$ MeV
b) the natural breadth of the ground state $\Gamma < 0,3$ MeV
c) angular distribution of neutrons: $\sigma(\theta)$=0,19+0,23 cos(θ)+ +0,70 $\cos^2(\theta)$ mb/steradian
d) mass defect of Be^6 = 20,3 ± 0,2 MeV
e) Reaction cross section for the ground state at Ep=9 MeV σ=5 ± 1 mb
2) $Li^7(p,n)$ Be^7
a) The neutrons corresponding to the ground state, the level with 0,43 MeV and 4,65 MeV were found,
b) The angular distribution for the neutrons of the ground state and the 1st level is $\sigma(\theta)$ = 6,8+2,4 $\cos^2(\theta)$ mb/steradian
c) The total reaction cross section (forming of ground state and 1st

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The Li(p,n)Be Reaction and the Fundamental Structure of the Be^6 Nucleus. 89-9-2/32

level) at Ep = 9 MeV:

$\sigma = 100 \pm 20$ mb

3) The neutrons of the following reactions were observed:

$Li^6(p,pn)\,Li^5$

$Li^6(p,2pn)\,He^4$.

(8 illustrations and 3 Slavic references).

ASSOCIATION Not Given.
PRESENTED BY
SUBMITTED 1.6.1957
AVAILABLE Library of Congress.
Card 2/2

24(7); 21(0) PHASE I BOOK EXPLOITATION SOV/1849

Rybakov, B. V. and V. A. Sidorov

Spektrometriya bystrykh neytronov (Spectrometry of Fast Neutrons) Moscow, Atomizdat, 1958. 175 p. (Series: Atomnaya energiya. Prilozheniye, 1958, Nr. 6) 8,050 copies printed.

Ed.: N.A. Vlasov; Tech. Ed.: S.M. Popova.

PURPOSE: This book is intended for engineers and technicians working in the field of experimental nuclear physics. It may also be used by advanced students majoring in physics.

COVERAGE: This volume is concerned with the spectrometric study of fast neutrons with energies ranging from 0.3 to 30 Mev. Main interest is focused on the time-of-flight method, a new approach to this energy range. This book is not only a review of work done on the time-of-flight method but also an original contribution of the authors based on experimental work done at the Institute of Atomic Energy. A general review is given of other methods in current use. References accompany each chapter.

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Spectrometry of Fast Neutrons SOV/1849

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Spectrometry of Fast Neutrons SOV/1849

Card 3/4

AVAILABLE: Library of Congress

TM/gmp
7-14-59

AUTHORS: Kurashov, A. A., Linev, A. F., Rybakov, B. V., Sidorov, V. A. SOV/89-5-2-6/36

TITLE: A Multichannel Time-of-Flight Fast Neutron Spectrometer (Mnogokanal'nyy spektrometr bystrykh neytronov po vremeni proleta)

PERIODICAL: Atomnaya energiya, 1958, Vol. 5, Nr 2, pp. 135-140 (USSR)

ABSTRACT: The novelty of the neutron spectrometer developed consists in the immediate use of the natural modulation of the cyclotron ray. The driving pulses which are synchronized by high frequency, are formed by means of a trigger. The trigger works with a pentode with secondary emission. The duration of the pulse is about 10^{-9} sec. The period of recurrence of a neutron pulse T is equal to the period of high frequency. For the simultaneous investigation of the time interval 2T, the generator for the driving pulses has to emit one pulse for two high frequency periods each. This is brought about by means of a frequency divider the input of which is fed by a sinusoidal voltage. The sinusoidal voltage is collected from the resonance lines of one of the cyclotron duants by means of a coil. The driving pulses with the 2T period pass on to a rapid coincidence scheme.

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A Multichannel Time-of-Flight Fast Neutron Spectrometer SOV/89-5-2-6/36

The main part of the time analyzer is the "phase" generator which is driven by the pulses of the scintillation counter. The generator is a trigger with delayed feedback and consists of a pentode with secondary emission. 150 m of the cable RK-2 are used as a delaying element in the system of delayed feedback. The length of the cable is chosen in such a manner that the period of the "phase" generator is equal to $8T-\Delta t$, where $\Delta t \approx 1.10^{-9}$ sec. The "phase" generator is always in action and is brought into phase by the pulse of the counting tube. (The fact that the counting tube pulse is used for switching on the generator leads to disturbing effects). The pulse of the anode of the multiplier FEU-33 reaches the input of the generator via a blocking valve and operates the input trigger, which emits two pulses. One of the pulses stops the generator and the second one releases the generator into phase again, viz. at the moment at which a neutron is recorded. The generator remains out of action for about 2,5 μseconds. An amplitude selector also belongs to the scheme of the spectrometer, the input of which is fed with the pulses of one of the dynodes of the multiplier. The amplitude selector is switched into

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the coincidence scheme by means of an input trigger. In this way it is possible to vary the effective threshold of the scintillation counter within wide ranges.
The operation of the time analyzer according to the nonius principle demands a high degree of constancy of the frequency differences. This is attained by means of a separate frequency stabilizer.
The width of a channel of the spectrometer amounts to about $1 \cdot 10^{-9}$ sec. The system of recording of the spectrometer consists of 256 channels; each channel is able to work up 2^{16} pulses. There are 5 figures and 13 references, 6 of which are Soviet.

SUBMITTED: May 14, 1958

21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-2/33

TITLE: Introduction (Vvedeniye)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 5-8 (USSR)

ABSTRACT: This paper deals with the spectroscopy of fast neutrons with energies of from about 0.3 to 30 Mev. The upper limit is natural from the viewpoint of applying neutron spectrometry to the investigation of nuclear structure, and is determined by the range of the discrete spectrum of energy levels. Moreover, energy limit of the neutrons of a certain group of sources (nuclear reactors, targets of a linear accelerator, of a Van-de-Graaf generator, and of a constant-frequency cyclotron) is within this interval. The lower limit of observation is only determined by the particular features of the methods of recording fast neutrons and is by far less definite. Until recently fast neutron spectra have been determined mainly from the spectra of the fast charged particles produced by the elastic scattering of neutrons on atomic nuclei ("nuclear recoil method") and by various nuclear reactions ("method of nuclear reactions"). Owing to the development of fast scintillation counters and since the

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development of the millimicrosecond pulse technique for the measurement of the energy of fast neutrons has made progress, it is possible to apply the time-of-flight method, already the classical method in experiments with slow neutrons, also to fast neutrons. This method already now furnishes more accurate results than other methods. According to the authors, this method is the most promising one in the fast neutron spectrometry. In order to obtain accurate results, the neutron source must provide a pulsed operation and a long range of measurement for measuring the flight time. In cases, where these conditions cannot be satisfied, the recoil nuclei and nuclear reaction methods maintain their prevalence. The method of threshold indicators (which is based upon the capture of neutrons under production of radioactive nuclei) gives only a rough outline of the neutron spectrum. The same holds true for the application of such threshold detectors as the fission chamber. The spectrometry of fast neutrons proved to be an excellent means of investigating nuclear forces and nuclear structure. A number of concepts used in neutron spectrometry are defined: the most important characteristics of a neutron spectrometer are resolving power, efficiency, and the dynamic range. Resolving power is defined as the ratio of the half-width of a line from a monoenergetic neutron current and of its energy: $\delta = \Delta E/E$. The efficiency of a detector for neutrons of a certain energy is usually specified by the probability for the recording of a neutron entering the sensitive volume of the detector. It is denoted by ε. The efficiency per sterad of a spectrometer is denoted by η: $\eta = \Omega\varepsilon$. The dynamic range of a spectrometer is designated by the quantity $q = E_{max}/E_{min}$, where E_{max} and E_{min} denote the maximum and minimum energy, respectively, accessible in one measurement. Most models of neutron spectrometers require a good collimation of the neutron beam. There are 4 references, 1 of which is Soviet.

21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-3/33

TITLE: Chapter I (Glava I). The Method of Recoil Nuclei (Metod yader otdachi)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 9-10 (USSR)

ABSTRACT: The elastic scattering of neutrons is the most simple kind of interaction between neutrons and atomic nuclei. It is possible to determine the spectrum of the neutrons from the spectrum of the recoil nuclei produced in this process. Even monoenergetic neutrons furnish a continuous energy distribution of the recoil nuclei. The energy of the recoil nuclei which are produced at a certain angle with respect to the neutron beam is uniquely dependent upon the energy of the neutrons. It is precisely this circumstance upon which the "differential method" of recoil nuclei is based, which is essentially that of determining the spectrum of the energy distribution of the recoil nuclei. The method is applicable only under favorable geometrical conditions. In the most simple cases it is sufficient to measure the complete spectrum of recoil nuclei (integrated over the angle of departure). In such cases the spectrum of the neutrons coming from extended

sources can also be studied (under adverse geometrical conditions). A great number of visual and electronic methods applicable to the principle of recoil nuclei for the investigation of the spectra of charged particles is available. Electronic methods feature a separation and measurement of the collimated beam of recoil nuclei by means of several proportional or scintillation counters forming a telescope. Among visual methods in neutron spectroscopy the method of thick photolayers is widely used, and it has been just this method to which the majority of the most interesting results of neutron spectrometry is due. This method is, however, rather cumbersome, and the results are available only a rather long time after the measurement has been made. As the methods of the spectrometry of fast neutrons advanced, the method of photoemulsions lost significance. The Wilson (cloud) chamber is at present hardly being used at all for the spectrometry of fast neutrons, whereas the bubble chamber gains in importance for the recording of very fast particles. With such bubble chambers it is possible to record fluxes of fast neutrons with a negligibly low intensity. There are 14 references, 3 of which are Soviet.

21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-4/33

TITLE: § 1. Fundamental Relations (§ 1. Osnovnyye sootnosheniya)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 10-13 (USSR)

ABSTRACT: In this section, the authors present the fundamental formulas for the determination of the neutron spectrum from the energy distribution of the recoil nuclei. The scattering of fast neutrons can in most cases be investigated in a non-relativistic approximation. Only near the upper limit of the neutron energies investigated (about 30 Mev) small relativistic corrections are sometimes necessary. The following relations apply: $E_A = \alpha E\cos^2\varphi$ with $\alpha = 4A/(1+A)^2$,

$$E' = \frac{E}{(1+A)^2}\left[\cos\theta \pm \sqrt{A^2 - \sin^2\theta}\right]^2,\quad \sin\varphi = \frac{1}{2}\sqrt{\alpha\frac{E}{E_A}\sin\psi},$$

$$\sin\theta = \frac{1}{2}\sqrt{\alpha A\frac{E}{E'}\sin\psi},\quad \sigma_\varphi = 4\sigma_\psi\cos\varphi,\quad \sigma_\theta = 4\frac{E'}{E}\frac{\sigma_\psi}{\alpha\sqrt{A^2 - \sin^2\theta}},$$

$E_A = (\alpha/2)E(1-\cos\psi)$. The probability that the recoil nucleus, owing to the scattering of a neutron with the energy E,

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acquires an energy ranging from E_A to $E_A + dE_A$ is $W(E_A)dE_A = (\sigma_\psi/\sigma)\cdot 2\pi \sin\psi d\psi$, where the angle ψ is taken from the above formula for E_A. This substitution gives $W(E_A)dE_A = (\sigma_\psi/\sigma)(4\pi/\alpha E)dE_A$. This formula connects the recoil nuclei spectrum occurring in the scattering of mono-energetic neutrons (i.e. the spectrum resulting from the recording of all recoil nuclei irrespectively of the angle) with the angular distribution of the scattered neutrons in the center-of-mass system. If the neutron spectrum is arbitrary, the following expression holds for the integral recoil nuclei spectrum:

$$W(E_A)dE_A = \text{const } dE_A \int_{E_A/\alpha}^{\infty} \sigma_\psi \frac{F(E)dE}{E},$$

where $F(E)dE$ denotes the number of neutrons with an energy of E to $E + dE$ in the measured spectrum, and the angle ψ is determined from the above formula. The differential scattering cross section of the neutrons in the center-of-mass system,

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which is under the integral sign, depends in the general case in a complicated manner upon the neutron energy. Determination of the neutron spectrum from the recoil nuclei spectrum therefore proves to be extremely difficult. If the neutron scattering in the center-of-mass system is isotropic, the analysis of the integral spectrum of the recoil nuclei is simplified considerably. In this case the integral spectrum of recoil nuclei is rectangular:
$W(E_A)dE_A = dE_A/\alpha E$, if $E_A < \alpha E$ or $W(E_A)dE_A = 0$ if $E_A > \alpha E$.
The limit of the spectrum provides the neutron energy and the area the total number of elastically scattered neutrons. The neutron spectrum is then
$F(E)dE = \text{const}\frac{E}{\sigma}\left[\frac{dW(E_A)}{dE_A}\right]_{E_A=\alpha E}.dE$. Hence it is possible to obtain the neutron spectrum by differentiating the integral recoil nuclei spectrum with respect to energy. It appears, however, that owing to the unavoidable distortions of the recoil nuclei spectrum by influences of the measuring apparatus this procedure can be used in neutron spectrometry only in the most simple cases, if the neutron spectrum

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§1. Fundamental Relations

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consists only of two or three lines which are sufficiently wide apart. The transition from the differential recoil nuclei spectrum to the neutron spectrum is reduced to the consideration of the energy dependence of the differential cross section of recoil nuclei production through a certain angle and hence to a linear conversion of the energy scale.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-5/33

TITLE: § 2. The Selection of the Radiating Substance (§ 2. Vybor radiatora)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 13-15 (USSR)

ABSTRACT: The following considerations are decisive in the selection of the substance for the investigation of the neutron spectrum: the recoil nucleus must be light, because the lighter it is, the more energy will be imparted to it. Besides, it is far easier to measure the energy of a light charged particle than that of a heavy one. The ranges of flight of particles heavier than α-particles are small and known with an accuracy far below that for protons and α-particles. The scintillation intensity caused by a heavy particle in a solid or fluid scintillator is very low. The elastic collision cross section of neutrons on the nuclei of the radiating substance may be considerably greater than the capture and non-elastic scattering cross section. This cross section must be well known, must depend only little upon the neutron energy, and must be sufficiently large. The neutron scattering in the center-of-mass system should be isotropic, because

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§2. The Selection of the Radiating Substance SOV/89S-58-6-5/33

this greatly simplifies the analysis of the recoil nuclei spectra and also increases the accuracy of the absolute measurement of the neutron fluxes. These requirements are satisfied best by hydrogen, which, in the majority of experiments, is used as a radiating substance. In some cases deuterium and helium are used. The total cross sections of the neutron scattering on these nuclei (as also the total cross section of the (n,p)-scattering are sufficiently large and also vary gradually with energy). Unlike (n,p)-scattering, neutron scattering on deuterium and helium nuclei is essentially forward-anisotropic. The use of helium is, for instance, convenient in cases where spectra of high-energy neutrons are studied by means of proportional counters. These counters operating under high pressure exhibit much better characteristics if filled with helium instead of hydrogen, because helium is a noble gas. There is 1 figure.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-6/33

TITLE: §3. The Scattering of Neutrons on Protons (§3. Rasseyaniye neytronov na protonakh)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 15-18 (USSR)

ABSTRACT: The formulas presented in the first paragraph of this chapter are much simpler than in the general case. The mass of the proton is with a very high accuracy equal to the mass of the neutron and hence in formula (5) given in paragraph one $\alpha = 1$ applies. The other formulas given in that paragraph are then reduced to

$E_p = E\cos^2\varphi = (1/2)E(1 - \cos\psi)$ (18); $E' = E\cos^2\theta$ (19); $\theta = \frac{\pi}{2} - \varphi = \frac{1}{2}\psi$ (20); $\sigma_\varphi = 4\sigma_\psi\cos\varphi$ (21); $\sigma_\theta = 4\sigma_\psi\cos\theta$ (22).

At neutron energies not exceeding 10 Mev the (n,p)-scattering is isotropic in the center-of-mass system. In this energy range is $\sigma_\varphi = \frac{\sigma\cos\varphi}{\pi}$ and $\sigma_\theta = \frac{\sigma\cos\theta}{\pi}$, where σ denotes the total cross section of the (n,p)-scattering at a given neutron energy. For neutrons with an energy exceeding 10 Mev, the

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differential cross-section in the center-of-mass system depends upon the angle and can be represented in the form $\sigma_\psi = \sigma_\psi(\frac{\pi}{2})(1 + C\cos^2\psi)$. The coefficient of anisotropy C also increases with increasing neutron energy. In a diagram the C versus energy function in the laboratory system is plotted. For the differential cross section of the neutrons in the laboratory system there

$$\sigma_\theta = \frac{\sigma\cos\theta}{\pi}\left[\frac{1 + 2\left(\frac{E}{90}\right)^2\cos^2 2\theta}{1 + 2/3\left(\frac{E}{90}\right)^2}\right]$$

applies. The total cross section of the (n,p)-scattering has been much investigated in a wide range of neutron energies. It may be described with a high accuracy by a semi-empiric formula derived by Gammel' (Ref 14):

$$\sigma = \frac{3\pi}{1.206E + (-1.8600 + 0.09415E + 0.000130E^2)} + \frac{\pi}{1.206E + (0.4223 + 0.1300E)^2},$$

where σ is given in barns and

§ 3. The Scattering of Neutrons on Protons SOV/89S-58-6-6/33

E in Mev. In many cases a simpler empiric formula may be used: $\sigma[\text{barn}] = \frac{4.83}{\sqrt{E(\text{Mev})}} - 0.578$. This formula in the energy range from 0.3 to 30 Mev gives results agreeing with an error of 3 % with experimental data. A table contains the values of the total cross section of the (n,p)-scattering computed according to the above formula. There are 1 figure and 1 table.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-7/33

TITLE: Chapter II (Glava II). A Telescope of Proportional and Scintillation Counters (Teleskop proportsional'nykh i stsintillyatsionnykh schetchikov)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, p 19 (USSR)

ABSTRACT: A system consisting of several counters for charged particles is termed a telescope, which permits the separation of a collimated beam of recoil protons and the measurement of their energy. The recoil protons in the telescope are derived from a layer of a hydrogen-containing substance ("radiator"). A distinction is made between telescopes with a "thin" and with a "thick" radiator. The first consists of a layer of a heavy hydrogen-containing substance as a radiator, and this layer is installed in front of the first counter of the telescope. Its thickness (upon which the resolution of the spectrometer is directly dependent) is only a few per cent of the range of flight of the recoil nuclei. In the second case the sensitive volume of the first counter of the telescope serves as a radiator. Its thickness may amount to

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Chapter II. A Telescope of Proportional and Scintillation Counters SOV/89S-58-6-7/33

a considerable portion (for example half) of the range of flight of the recoil protons and it is only limited by the necessity of recording the recoil proton by the other counters of the telescope. A telescope with a thin radiator may have a considerably high resolution (as much as 5 %) and hence may be used for the study of complicated neutron spectra. If satisfactory results are required very intensive neutron fluxes are necessary. The main advantage of such a spectrometer is found in the possibility to compute its efficiency for mono-energetic neutrons with an accuracy which is only determined by the uncertainty in the cross section of the (n,p)-scattering. It is mostly for this reason that telescopes with a thin radiator are frequently used for the absolute measurement of mono-energetic neutron fluxes. A telescope with a thick radiator has a much higher efficiency and is used for the investigation of low-intensity neutron fluxes. There are 38 references, 7 of which are Soviet.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-8/33

TITLE: § 1. A Telescope With a Thin Radiator (§ 1. Teleskop s tonkim radiatorom)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 19-39 (USSR)

ABSTRACT: In a figure the experimental arrangement for the measurement of a neutron spectrum with a thin radiator is shown. A hydrogen-containing radiator is located at a distance b_1 from the neutron source S. This radiator has a diameter 2a. The recoil protons emitted in the direction of the recording system are collimated by a diaphragm which is located at the distance b_2 from the radiator. The geometrical conditions are practically everywhere well satisfied so that the neutron source may be considered to be punctiform. The diameters of the radiator and of the diaphragm are small as compared to b_1 and b_2. In this instance only that case is investigated, in which the diameter of the diaphragm equals that of the radiator. Between the radiator and the diaphragm and behind the diaphragm counters for charged particles are installed, sometimes also

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slowing-down filters. The counter "telescope" and its auxiliaries separate from the totality of particles produced in it those recoil protons which have left the radiator and have passed through the diaphragm. This makes it possible to measure their energy distribution. The authors then investigate the resolution and the efficiency of a telescope with a thin radiator. A small reserve in resolution considerably increases the efficiency of the telescope. For this reason "wide-angle" telescopes must be used for absolute measurements of mono-energetic neutron fluxes, which have a relatively low resolution. The maximum counting rate at a given resolution of the telescope is computed. In a figure the electronic block-scheme of the telescope is shown. It permits a simultaneous recording of coincidences of the type 1+2, 1+2+3, 1+2+3+4, and 1+2+3-4. These digits denote the numbers of the counters and the minus sign corresponds to an anti-coincidence. The recording of coincidences of the type 1+2+3-4 provides the differential spectrum of the recoil protons and hence also the neutron spectrum. The spectrometer described in this paper has been used for the investigation of the excitation curve of the reaction $T(p,n)He^3$ in the range of proton

6 1. A Telescope With a Thin Radiator SOV/89S-58-6-8/33

energies of from 7-12 Mev. In another figure the typical lay-out of a scintillation counter telescope is given. The disadvantage of this telescope is its high sensitivity to a γ-background. At the end of this paragraph the auxiliary operations and corrections are enumerated which must be carried out in order to obtain accurate results. There are 14 figures.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-9/33

TITLE: § 2. A Telescope With a Thick Radiator (§ 2. Teleskop s tolstym radiatorom)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 40-52 (USSR)

ABSTRACT: The sensitive volume of the first counter of the telescope may also be used as a source for recoil protons, if it is filled with hydrogen. When the energy of such a proton is determined from the intensity of the ionization produced by it or from the scintillation flashes, the thickness of such a radiator may take up quite a proportion of the range of flight of the proton, because the energy lost by it in the radiator is measured. Hence it is possible to increase the efficiency of the counter and in some cases to minimize the energy-dependent limit of applicability to a few dozens kev. The authors then investigate several typical variants of ionization and scintillation telescopes with a thick radiator. One figure, for example, shows an ionization telescope for neutron energies from 0.05-1 Mev composed of three proportional counters filled with methane. Another spectrometer designed by Mozley and Shoemaker (Ref 29) was constructed as a

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§2. A Telescope With a Thick Radiator

telescope with two organic scintillation counters. Calvert et al. (Ref 30) constructed a better telescope of the same type. Various authors (Refs 31-36) proposed another system for the spectrometry of fast neutrons analogous to a γ-spectrometer with two crystals and based upon the Compton effect. Such systems have hitherto hardly ever been used in practice. There appeared, however, the prototype of a spectrometer measuring the energy of the neutrons from the transit time required by the neutrons to pass the distance between two counters. The principal design of such a spectrometer is shown by a figure. In order to suppress the background, the resolving time of the coincidence circuit is made sufficiently small. The resolution power of the spectrometer is primarily determined by the inaccuracy in the recording of neutrons scattered through a certain angle and by the resolution γ (with respect to the amplitude) of the first counter. The spectrometer described by Beghian et al (Ref 31) is mentioned as being interesting. The authors maintain, however, that this spectrometer has only a low resolution.

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§ 2. A Telescope With a Thick Radiator SOV/89S-58-6-9/33

A telescope reaches its maximum efficiency, if it is filled with pure hydrogen. There are 10 figures.

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21(3)

AUTHORS: ~~Rybakov, B. V.,~~ Sidorov, V. A. SOV/89S-58-6-10/33

TITLE: Chapter III (Glava III). The Method of Nuclear Reactions (Metod yadernykh reaktsiy)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 53-55 (USSR)

ABSTRACT: When a neutron causes a nuclear reaction in which only charged particles are produced, the energy of the neutron may be determined by a summation of the total energy of the charged particles derived from their ranges in a thick photographic emulsion. As now the total energy of the particles produced by the neutron causing the reaction is independent of the direction of incidence, this method does not call for a previous collimation of the neutron beam. For this reason this method is particularly well suited for measuring the spectrum of extended sources. It is used in the investigation of nuclear reactors and in experiments concerning the development of neutron flux shields. In such cases the use of spectrometers which are based upon the recoil nuclei principle leads to two fundamental disadvantages connected with the necessity of collimating the neutron beam. Firstly, the spectrometer must be placed at a considerable distance from the neutron

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source, which greatly reduces its efficiency, and secondly the scattering of neutrons on the walls of the collimator to a small extent distorts the primary neutron spectrum. The choice of nuclear reactions suited for the study of the spectrum of fast neutrons is very limited, as the reaction cross section must be sufficiently large and in the energy range under investigation be only little dependent upon energy. Moreover, the reaction must comply with the following contradictory requirements: The nucleus produced by the reaction should not have low excited levels as otherwise the total kinetic energy of the reaction products would not follow a unique relationship with the energy of the neutron. This requirement can only be fulfilled with very light nuclei. On the other hand, the nucleus must be sufficiently heavy in order to ensure that in an elastic collision of a neutron with maximum energy on this nucleus the energy of the recoil nucleus is lower than the total energy of the reaction products. The higher the energy Q of the reaction, the better will this requirement be complied with. If, however, Q is large and positive, the energy of the neutron is only a small proportion of the energy of the reaction products and hence the accuracy of measurement is diminished. Finally it is required that every other reaction possible between the neutron and the same nucleus must be either much less advantageous or much less probable. Only very few reactions between a neutron and a light nucleus meet these requirements. In a diagram the curves describing the cross section of the most advantageous reactions $He^3(n,p)T$ and $Li^6(n,\alpha)T$ versus the neutron energy are shown. The nuclear reaction method is used for the measurement of neutron spectra with the help of thick photographic emulsions. An additional criterion for the choice of the nuclear reaction is in this case the existence of a characteristic and easily recognizable track in the emulsion. Usually, such emulsions are used for neutron spectrometry, which are sensitized with boron or lithium. The reaction $B^{10}(n,2\alpha)T$ ($Q = 0.33$ Mev) provides an easily recognizable three-track star. The reactions $Li^6(n,\alpha)He^3$ ($Q = 4.78$ Mev) and $B^{11}(n,\alpha)Li^8$ ($Q = -6.7$ Mev) are also easily identifiable, the latter on the strength of the lithium "hammers" which are produced by the decay of Li^8. There are 1 figure and 13 references, 3 of which are Soviet.

21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-11/33

TITLE: §1. An Ionization Spectrometer With He^3 (§1. Ionizatsionnyy spektrometr s He^3)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 55-58 (USSR)

ABSTRACT: When an isotope exhibiting a suitable reaction under the interaction with a neutron is introduced into the gas of an ionization chamber or of a proportional counter, the energy of the reaction products can be determined from the ionization produced by them. Batchelor et al (Refs 5,6,7,8,9) for this purpose used a proportional counter containing He^3. The total energy of the proton and the triton was measured, which are generated in the reaction $He^3(n,p)T$ ($Q = 0.77$ Mev). In two diagrams the counter pulse spectra originating from its being irradiated by mono-energetic neutrons with energies of 0.12 and 1.00 Mev are shown. Apart from the main peak there appears in every spectrum a peak originating from the slow neutrons (caused by the slowing-down of primary neutrons in the walls of the apparatus) and a continuous spectrum originating from the γ-radiation. The peak is caused by an acute increase of the cross section of the reaction $He^3(n,p)T$ for

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91. An Ionization Spectrometer With He^3 SOV/89S-58-6-11/33

slow neutrons. If the neutron energy is 1 Mev the pulses of even such recoil nuclei become visible as are produced by an elastic scattering of neutrons on He^3. The lower limit of the energy range covered by the spectrometer is about 0.1 Mev, where also the main peak merges with the peak due to the slow neutrons. This spectrometer is suited for the measurement of the spectrum between 0.1 and 1 Mev. The main field of application of a spectrometer making use of the reaction $He^3(n,p)T$ is near a neutron energy of 1 Mev. The design of the proportional counter must guarantee a high resolution and the absence of edge effects. If the counter has conventional dimensions a heavy gas (Ar,Kr,Xe) must be added to the He^3 and the pressure of the mixture must be raised to several atmospheres in order to reduce the range of flight of the charged particles produced in it. This, however, meets with considerable technical difficulties. The resolution of the counter constructed by Batchelor et al was about 7 %. N. P. Glazkov with a simpler spectrometer achieved almost the same resolution. His spectrometer consisted of a spherical chamber filled with He^3. The resolution of the proportional counter and of the ionization chamber depends much on the purity of the gas used, in partic-

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61. An Ionization Spectrometer With He^3 SOV/89S-58-6-11/33

ular at high pressures. In the apparatus discussed, the gas had been carefully purified. The efficiency of the He^3 spectrometer can be computed by using the energy dependence of the reaction $He^3(n,p)T$, which is plotted in a diagram. A considerable advantage of a spherical ionization chamber as compared to a cylindrical proportional counter is the independence of the efficiency from the direction of the incident neutrons. There are 3 figures.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-12/33

TITLE: § 2. Scintillation Spectrometer With a $Li^6J(Eu)$ Crystal (§ 2. Stsintillyatsionnyy spektrometr s kristallom $Li^6J(Eu)$

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 58-63 (USSR)

ABSTRACT: A higher efficiency than that of the He^3 spectrometer described in § 1 of this chapter can be attained by the following means: The isotope which is the reaction substance is introduced into the solid scintillator and the energy of the neutron is determined from the pulse of the scintillation counter. This method meets with one important difficulty, viz., that the light yield of the scintillator decreases considerably with increasing specific ionization (produced by the charged particle). If several charged particles are produced in the reaction caused by the neutron, their total energy (which for a given neutron energy is naturally constant) may be divided among them in a different manner. If different particles are produced in one reaction (for example α-particles and tritons) this leads to great differences in the pulse heights. This difficulty was almost completely overcome by R. B. Murray (Ref 12). He used

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§ 2. Scintillation Spectrometer With a $Li^6J(Eu)$ Crystal SOV/89S-58-6-12/33

a lithium iodide crystal (from the pure isotope Li^6) which had been activated with europium as a scintillation detector for neutrons. When the crystal is cooled to -140°C the deviation of the pulse heights decreases. Thus, a quite acceptable resolving power can be attained. The apparatus of Murray which permits to vary the temperature of the crystal between room temperature and the temperature of liquid nitrogen is represented in a figure. In a diagram the pulse spectra of the counter are shown, which were found at varying temperatures by irradiating the crystal with mono-energetic neutrons with an energy of 5.3 Mev. If the temperature of the crystal is reduced to -142°C the main peak width decreases to almost half its original value, whereas the pulse height increases by a factor of 1.5. At low temperatures the peak takes the shape of a Gaussian curve. The resolving power of the spectrometer is below that of the counter with respect to the pulse height. The high Q permits to attain a good discrimination of the γ-rays. In another diagram the dependence of the efficiency of a $Li^6J(Eu)$ crystal on the neutron energy is plotted. The efficiency decreases rapidly with increasing energy.

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§ 2. Scintillation Spectrometer With a $Li^6J(Eu)$ Crystal SOV/89S-58-6-12/33

At E = 10 Mev, however, it is still sufficiently high. This spectrometer has only a limited applicability, as its efficiency for slow neutrons is very high. If Soviet photomultipliers of the type FEU-11 (or also FEU-12 or FEU-16) are used, which operate normally at the temperature of liquid nitrogen, the crystal can be applied directly to the photocathode. By this procedure the characteristics of the spectrometer are considerably improved. The lower limit of applicability of this spectrometer corresponds to a neutron energy of 1 Mev. There are 5 figures.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-13/33

TITLE: Chapter IV. The Time-of-flight Method (Glava IV. Metod vremeni proleta)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 64-66 (USSR)

ABSTRACT: The determination of the neutron energy from the time-of-flight is the most direct method of neutron spectrometry. The time-of-flight is connected with the neutron energy and the distance traveled by the neutron by the relationship

$t_{m\mu sec} = \tau L = 72.3L(m)/\sqrt{E(Mev)}$. τ denotes the time the neutron requires for traveling the distance of 1 m. The above formula is given in its non-relativistic approximation. If the energy of fast neutrons is measured with high accuracy the relativistic effect must also be taken into account. In the case of a neutron energy of 30 Mev the relativistic correction amounts to ~ 3 %. The relation between the neutron energy spectrum and their distribution over the time-of-flight is described by the equation $F(E)dE = V(t)dt = U(\tau)d\tau$. If the above given formula is taken into consideration, the following expression is derived

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Chapter IV. The Time-of-flight Method

for the conversion of the neutron spectrum from the time into energy scale: $F(E)dE = 0.957 \cdot 10^{-4} \tau^3 U(\tau)dE$, where τ is measured in mμsec. The arrival of the neutron at the extremity of the flight path is recorded by the occurrence of the pulse in the counter. The moment of departure may be recorded by one of the following methods: 1) recording of the neutron scattering in an organic scintillation counter which is installed at the beginning of the flight path. 2) recording of the radiation accompanying the production of a neutron by a nuclear reaction by means of a counter installed near the neutron source. 3) The use of a pulsed neutron source. In the spectrometry of slow neutrons only the third method is used. Time-of-flight spectrometers have a resolution time of the order of ~1 μsec. The application of time-of-flight methods to fast neutrons has been made possible only in recent years owing to the development of scintillation counters with organic scintillators of fast coincidence circuits, of wide-band amplifiers and oscillographs and of fast triggers. The technique of producing neutron pulses lagged somewhat behind the development of fast scintillation counters and time analyzers. Hence, in the beginning, spectrometers with two

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counters predominated, which are based upon the first two above mentioned methods of recording the moment of departure of the neutron. There is 1 figure.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A. SOV/89S-58-6-14/33

TITLE: § 1. A Spectrometer With Two Counters (§ 1. Spektrometr s dvumya schetchikami)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 66-70 (USSR)

ABSTRACT: A spectrometer, in which the scattering of a neutron by a counter into a counter is recorded for the determination of the departure time of the neutron has the same design as the two-crystal counters described in § 2., chapter II. It differs only in that respect that the principal feature is the analysis of the scattered neutrons by determining the time of flight instead of the amplitude analysis of the recoil protons in the first counter. One of the first spectrometers of this type has been designed by A. I. Veretennikov and V. Ya. Averchenkov (Ref 3). The authors devote themselves to a closer study of the apparatus described by G. C. Neilson and D. James (Ref 4). The neutron is scattered in the organic scintillator through the angle θ_o and is recorded by the second counter. The neutron distribution over the time of flight is measured. The counters consist of two stilbene crystals and of a photomultiplier of the type RCA 6342. The pulses of the photomultiplier are then

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transmitted to a 30-channel time analyzer, which operates on the principle of time-amplitude transformation. The resolution time of the spectrometer is 1.5 mμsec, which is near to the best results ever attained by such apparatus. Notwithstanding this achievement it is necessary to place the counters at a considerable distance from one another in order to achieve a sufficiently high resolving power of the counters. This again reduces the efficiency of the spectrometer. The width of the neutron peaks is mostly determined by the blurring of the scattering angle owing to the finite dimensions of the crystals. The main disadvantage of such a spectrometer is its low efficiency, which cannot be compensated by the use of high-intensity neutron sources. In a diagram the neutron spectrum of the reaction $Be^9(d,n\gamma)B^{10}$(E_d = 0.8 Mev) is shown, which has been recorded by a Neilson-James spectrometer with its first γ-radiation counter. Three groups of neutrons are found above a dense background which is due to accidental and "wrong" coincidences, which correspond to the lower excited levels of B^{10}. The neutron energies determined from this information,

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4.20 + 0.40; 2.65 ± 0.30; and 1.28 ± 0.20 Mev, well agree with the energies determined with the thick photolayer method. They are, however, less accurate. The spectrometers with two counters discussed in this paragraph exhibit in spite of their many shortcomings many advantages as compared to the counters described in § 2 of chapter II. They are particularly suited for the observation of several groups with different energies in a wide range of neutron energies, and to the n-γ-correlation for a single energy group above a dense background of neutrons with other energies. Such a spectrometer is particularly useful if the radiation accompanying the neutron consists of charged particles. There are 3 figures.

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21(3) SOV/89S-58-6-15/33

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 2. A Spectrometer With a Pulsed Neutron Source
(§ 2. Spektrometr s impul'snyn istochnikom neytronov)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 70-73 (USSR)

ABSTRACT: The utilization of a modulated source for marking the moment of departure of the neutrons permits using only one counter in the time-of-flight spectrometer. This considerably increases the efficiency of the spectrometer and eliminates the limitations imposed upon the neutron current, which are due to the overloading of the first counter and to accidental coincidences. This modulated neutron source produces short periodic neutron pulses, which are separated by sufficiently long intervals. The difficulty in realizing such a spectroscopic method in the megavolt range is that a pulse duration of one mμsec is required for attaining a sufficiently high resolving power. The technique of producing ultrashort pulses has been developed only in most recent times. Only a few methods have hitherto become known of modulating beams of charged particles produced by accelerators, so that only the target of an accelerator is used as a source

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of pulsed neutrons. Owing to the particular features encountered in the acceleration of fast particles a cyclotron is particularly well suited as a "natural" pulsed source for the spectrometry of fast neutrons. In a figure the principal lay-out of a modern time-of-flight spectrometer for fast neutrons is shown. The main elements of this spectrometer are the pulsed neutron source, the neutron detector, and the time analyzer. When primary reactions are investigated a sample is used as a source, which emits neutrons under the irradiation with a pulsed beam of mono-energetic neutrons. This pulsed neutron beam is also produced in the target of an accelerator. The flight length between the source and the neutron detector (also termed "basis") attains values of $\sim$10 m with primary reactions and of $\sim$1 m for the investigation of secondary reactions (as, for example, the non-elastic scattering of neutrons). The pulses of the neutron detector are then transmitted to the input of the time analyzer. The other input of the time analyzer receives signals which are synchronized with the neutron pulses. The time analyzer analyzes the time distribution of the counter pulses with respect to the control pulses. This distribution represents apart from a constant

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time shift the neutron distribution over the times of flight. A valve governed by the signal of the amplitude selector opens only when the amplitude of the neutron counter pulse is within the prescribed interval and thus permits the passage of the pulse coming from the time analyzer. The amplitude selector is not indispensable in the spectrometer, it only serves to determine the neutron energy. There is 1 figure.

21(3) SOV/89S-58-6-16/33

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: Chapter V (Glava V). A Pulsed Neutron Source (Impul'snyy istochnik neytronov)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, p 74 (USSR)

ABSTRACT: The time-of-flight spectrometers existing nowadays without an exception use the targets of various accelerators as a pulsed neutron source. The technique of producing short neutron pulses reduces to different methods of modulating the beam intensity of charged particles. As the slowing-down of the particles in the target and the nuclear reaction both take only a very short time the moment of neutron emission coincides with the moment of incidence of the charged particles upon the target and hence the duration of the neutron pulse equals that of the charged particles pulse. The optimum pulse length is 1 mμsec. A further diminution of this length only leads to a loss of average intensity and contributes nothing towards a better resolving time of the spectrometer. Hence the resolving time of the scintillation counter may be considered completely satisfactory. The problem of the optimum pulse repetition frequency is investigated in § 3 of chapter 8. In most cases the

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necessary pulse repetition frequency is about 1 mc.
There are 39 references, 9 of which are Soviet.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 1. Beam Modulation of an Electrostatic Accelerator
(§ 1. Modulyatsiya puchka elektrostaticheskogo uskoritelya)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 74-83 (USSR)

ABSTRACT: A linear accelerator and a Van de Graaf generator produce a continuous well focussed ion beam of a relatively low energy. The following simple method is often used for the modulation of this beam: A pair of deflecting plates (to which a sinusoidal high-frequent voltage is applied) and a diaphragm periodically interrupt the beam. The higher the amplitude of the chopping frequency is the lower the pulse length of the particles striking the target will be. If the chopping frequency is raised to about 1 megacycle it can easily be reduced to 1 mμ.sec. If it is desirable to have only one neutron pulse per high-frequency period, this can easily be attained. This method is much used owing to its simplicity, it has, however, also considerable disadvantages: The average neutron flux striking the target is only a small proportion of the initial intensity of the beam. In a diagram the interruptor system used with the Van de Graaf generator in Los Alamos is shown.

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The interruptor is placed directly at the exit of the beam from the magnet. Many shortcomings of this system can be avoided if the beam interruptor is placed at the accelerator entrance immediately behind the source. Thus the accelerator is freed from a superfluous load and the ratio between the effect and the background is considerably increased. Some interruptors of this type are portrayed in figures and discussed. In order to increase the instantaneous flux of charged particles under pulsed operation various methods of ion grouping can be used. The method advanced by R. C. Mobley has hitherto never been used, as it requires a deflecting voltage of 100 kv and a large magnet. Another highly effective method of ion grouping due to N. N. Flerov and Ye. A. Tamanov is discussed. This method has the disadvantage that the beam is to a certain extent divergent. Finally the method of increasing the intensity of the neutron pulse proposed by F. L. Shapiro is discussed. There are 7 figures.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 2. The Utilization of the Natural Modulation of a Cyclotron Beam (§ 2. Ispol'zovaniye yestestvennoy modulyatsii puchka tsiklotrona)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 83-90 (USSR)

ABSTRACT: A cyclotron accelerator operates on the principle that only such particles reach the terminal radius which gyrate between the duants in phase with the accelerating high frequency tension. The expulsion of the particles from the chamber by means of an electrostatic deflector further narrows the useful phase interval. Hence, the particles are emitted by the cyclotron once within the period of the high-frequency tension. The duration of this pulse is in a constant-frequency cyclotron ostensibly only a few percent of the high-frequency period. The 150 cm-cyclotron of the IAE AN SSSR (Institute of Atomic Energy AS USSR) at a certain synchronization delivers particle pulses with a duration of 3 mμ.sec (the high-frequency period being 100 mμ.sec). The width of the particle pulses depends upon the synchronization of the cyclotron. The pulse width is known to increase with increasing amplitude of the high-frequency tension and it also depends upon the deflecting

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§ 2. The Utilization of the Natural Modulation of a Cyclotron Beam

voltage. If the cyclotron is tuned out of resonance, this width decreases. In cyclotrons used for neutron work the beam is focused onto a target which is located a long distance from the target behind a concrete or water shield. The authors then calculate the influence exerted by the deviation from monochromacy upon the proton pulse length. The intensity of the beam striking the remote target is in most cyclotrons of the order 10 microamps. From this can be seen that the cyclotron is a very convenient "natural" pulsed source of neutrons. A number of methods dealing with a reduction of the pulse repetition frequency of the cyclotron beam are discussed. The intensity of the neutron flux produced by a large cyclotron is sufficient for many spectrometrical experiments with fast neutrons. Such a neutron source is particularly suited for the spectrometry of kilovolt neutrons by means of time-of-flight methods. There are 6 figures.

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21(3) SOV/89S-58-6-19/33

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 3. The Determination of the "Time Marks" (§ 3. Polucheniye "metok vremeni")

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 90-92 (USSR)

ABSTRACT: In the flight time analysis of neutrons it is necessary to have "time marks" that is to say, electrical ("control") signals which are synchronized with the neutron pulses. The most direct method of determining the "time marks" is to make use of the energy pulses which are produced on the target when it is struck by incident particles. This method is of interest in particular with a cyclotron because by this means it is possible to eliminate its phase instability. However, it is only with great difficulties that this method can be realized in practice and it is therefore only rarely used. A figure shows the circuits used by R. Grismore and W. C. Parkinson (Ref 22) for the production of pulses with a target of the cyclotron of Michigan University. The accelerated particles were completely absorbed by a lead plate. The pulses derived from the target have a duration of 20 mμsec if the pulses of the incident par-

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ticles have a duration of ~ 4 mμsec. If the beam has a medium intensity the pulse amplitude is ~ 10 mv. Previous to being transmitted to the chronotron the pulses must be amplified by a broad-band amplifier. A great disadvantage of such a system is that the pulse amplitude depends upon the beam intensity. Moreover, with such a system stringent limitations are placed upon the design of the target which in some cases are incompatible with the experimental requirements. If the target of the accelerator is used as a source of monochromatic neutrons in the study of secondary processes these errors are less influential. Another method of producing a control pulse is found in the recording of a part of the accelerated particles by a fast scintillation counter which has been placed near the target. Sometimes it is possible to obtain a scintillation pulse directly from a gaseous target. A production of control pulses by means of a scintillation counter recording the primary particles leads to great difficulties in the time analysis as such a counter does not produce standard pulses. The amplitude of such pulses is strongly dependent upon the beam intensity. The practically most convenient method of producing control pulses for the determination of the "time marks" is the instal-

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lation of an interruptor which effects the modulation of the beam. This greatly simplifies the control pulse generation as by this means the dependence of their position and amplitude upon the beam intensity is completely eliminated. For a cyclotron there arise still some difficulties because the phase of particle emission depends upon the synchronization of the cyclotron. The uncontrollable variation of the operational data of the cyclotron may lead to a considerable distortion of results. When a tentative measurement was carried out with the cyclotron of the IAE (Institute of Atomic Energy) it was found that the position of the γ-peak varied by ± 10 mμsec if the variation of the operational data of the cyclotron did result in a variation of the beam intensity by factor not exceeding 10. There is 1 figure.

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21(3) SOV/89S-58-6-20/33

AUTHORS: Rybakov, ~~B. V.,~~ Sidorov, V. A.

TITLE: Chapter VI (Glava VI). The Neutron Detector (Detektor neytronov)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, p 94 (USSR)

ABSTRACT: In time-of-flight spectrometers it is customary to use an organic scintillation counter for the neutron detection which records the neutrons by their recoil protons. In case of special problems gaseous scintillators may also be used. General information on scintillation counters may be found in numerous handbooks and manuals (Refs 1-7). This chapter deals with the most important design data of the counter - the efficiency of neutron recording and the resolution time. There are 53 references, 26 of which are Soviet.

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21(3).

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 1. The Efficiency of a Counter With an Organic Scintillator (§ 1. Effektivnost' schetchika s organicheskim stsintillyatorom)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 94-110 (USSR)

ABSTRACT: A scintillation counter recording neutrons by their recoil protons, does not differ principally from an ionization chamber filled with gaseous hydrogen. It permits to investigate simple neutron spectra by means of the integral method of recoil nuclei, as with an ionization chamber, and also to make absolute measurements of mono-energetic neutron fluxes. The high efficiency of the scintillation counter and the possibility of absolute neutron flux measurements are made use of in a time-of-flight spectrometer, where the spectrometer may be considered as a detector of mono-energetic neutrons. If an arbitrary neutron spectrum is considered, which is usually accompanied by a γ-radiation background a given channel of a multichannel time analyzer (or a single-channel analyzer) selects only such neutron pulses from the totality of counter pulses, the energy of which has been determined by their time of flight. For the

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efficiency of the counter with respect to neutrons with the energy E there holds $\varepsilon = nh\sigma(1 - (B/E))$. In this formula n denotes the number of hydrogen atoms per unit volume of the scintillator, h the thickness of the scintillator (which is assumed small as compared with the mean free path) and σ the total cross section for the (n,p) scattering. If the threshold of the counter (measured in terms of the neutron energy) is known, the above given formula specifies the efficiency versus energy function of this counter and the absolute value of the efficiency. In a diagram the integral and the differential spectrum of a scintillation counter with a stilbene crystal which have been taken with a neutron energy of 9 Mev are shown. The shape of these spectra agrees extremely well with the shape of the energy distribution of the recoil protons. The blurring at the upper edge of the spectrum is caused by the finite resolving power of the counter (with respect to the amplitude) and the increase in the vicinity of the origin is mainly due to the non-linear dependence of the light yield of the scintillator upon the proton energy. Finally several secondary effects are investigated which may modify the efficiency of the counter:

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Interaction of the neutrons with the carbon nuclei, attenuation of the neutron flux in the scintillator, edge effects, multiple (n,p) scattering, anisotropic (n,p) scattering. Under certain conditions (which are usually satisfied) the formula $\varepsilon = nh\sigma(1 - (B/E))$ is accurate with an error not exceeding 10%. The energy dependence of the efficiency computed by the revised formula $\varepsilon' = \frac{\sigma}{\sigma + \sigma_c}\left(1 - e^{-nh(\sigma + \sigma_c)}\right)$ and its absolute value agree extremely well with experimental data. In this formula, σ_c denotes the cross section of the non-elastic interaction of neutrons with carbon atoms. There are 8 figures and 2 tables.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 2. The Resolving Time (§ 2. Razreshayushcheye vremya)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, pp 110-115 (USSR)

ABSTRACT: In order to simplify the considerations the authors limit themselves to the discussion of a scintillation counter which is based upon a time-of-flight spectrometer. An idealized picture is drawn in order to elucidate which requirements must be satisfied by a "fast" scintillation counter. The number of photoelectrons contained in the pulse is considered to be so large as to justify the neglect of all statistical effects. The anode of the linear multiplier is connected with the input of a trigger. The pulses reaching the anode of the multiplier shall differ only with respect to their amplitude V_o, their shape being described by the curve $f(t)$ (which is shown in a diagram). The moment when the trigger trips is exclusively determined by the point where the voltage $V(t) = V_o f(t)$ at its input has risen to a certain value V_{tr} (threshold of the trig-

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ger). The authors then investigate a limited range of voltage rise at the anode of the photomultiplier, which corresponds to the dynamic amplitude range $1 + \alpha$ ($\alpha \ll 1$). The shape of this curve is determined by the following factors: 1) The excitation time of the scintillator in the energy range investigated is very small. 2) The light accumulation of the scintillator by the photocathode may, with a high degree of approximation, be described by the law $e^{-t/hc}$, h denoting the linear dimensions of the scintillator. If $h < 10$ cm the light accumulation time is negligible. 3) The de-excitation of the majority of organic scintillators is described fairly well by an exponential law. 4) The inaccuracies of the time of flight of the photoelectrons to the first dynode in general provide the main proportion of the resolution time of the scintillation counter which contains a photomultiplier with a large photocathode. 5) If the number of neutrons is multiplied (the basic characteristics of a multiplier system) the blurring of the pulse takes a shape sufficiently well approximating a Gaussian curve. The superposition of these factors determines the shape of the anodic current pulse of the photomultiplier. If coincidence circuits are

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used which incorporate germanium diodes an amplification factor of $\sim 10^6$ is mostly sufficient. The authors then investigate the statistical limitations of the resolution time of the scintillator. The following assumptions are made: 1) The time required for the excitation of the scintillator and for the light accumulation on the photocathode is negligibly small. 2) The photomultiplier causes no time deviations. 3) The input trigger of the time analyzer trips at that moment, at which a certain number of pulses (coming from the individual photoelectrons) have been accumulated at its input. If a considerable suppression of the statistical component of the resolution time of the scintillation counter is desired, the following requirements must be satisfied: 1) The ratio (P/τ_0) must be large, P denoting the light yield and τ_0 the de-excitation time of the scintillator. 2) A high accumulation coefficient of photons on the photocathode. 3) A high sensitivity of the photocathode in the spectral range of the scintillator luminescence and a complete accumulation of the photoelectrons on the first dynode. 4) A low effective threshold value of the time analyzer. There is 1 figure.

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21 (3) SOV/89S-58-6-23/33

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: § 3. The Characteristics of a Few Scintillators and Photomultipliers (§ 3. Kharakteristiki nekotorykh stsintillyatorov i fotoumnozhiteley)

PERIODICAL: Atomnaya energiya 1958, Supplement, Nr 6, pp 115 - 122 (USSR)

ABSTRACT: The most important properties of the organic scintillators most used in neutron spectrometry are compiled in a table. The relative pulse amplitudes were measured with a photomultiplier by means of small targets, the photomultiplier having an antimony-cesium photocathode and a so-called "mean" spectral characteristic. These measurements were carried out with a β-particle excitation. In a diagram the light yield versus proton energy function for a stilbene crystal is shown. The light yield and the luminescence period of the scintillators listed in the table differ only little. The prevalence of one or the other scintillator proceeds from the experimental conditions. The standard stilbene crystals have 3 cm diameter, a height of 2 cm or also a diameter of 4 cm and a height of 4 cm. Tolan crystals are available as cylinders with 10 cm diameter and 5 cm height. Solutions of terphenyl in toluene (which have the highest ini-

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tial de-excitation rate among the scintillators listed) are used only in small containers. If a substance is added which displaces the emission spectrum of the scintillator towards greater wavelengths, the transparency and the light yield are increased, which permits the use of large-sized scintillators. The light yield of liquid scintillators is highly dependent upon the purity of the substances used, which requires their special purification and the use of suitable container materials. Large containers are often made of aluminum and are polished on the inside. The plastic materials mentioned in the table exhibit a high transparency to natural radiation and can be used in large sizes. Reference is made to more detailed information on organic scintillators. Only in most recent times (1955 - 1957) the technique of gas scintillators has been developed in which the luminescence of noble gases under the action of ionizing particles is utilized. They have, apart from a relatively slow de-excitation component (of the order of tens of mμsec), also a fast component ($\tau_0 \sim 1$ mμsec), which is due to the luminescence of the excited atoms. Their application is rendered difficult

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by the circumstance that the luminescence spectrum of the noble gases is in the ultraviolet range. Most recently, however, highly effective substances causing a displacement of the spectrum to the range of high sensitivity of the cathode of the photomultiplier have been found. The best among them - quaterphenyl - has a de-excitation time of less than 8 mμsec and can be used also in fast counters. The most valuable property of gaseous scintillators is the fact that their light yield versus energy function is practically independent of the specific ionization and hence is equal for different particles. This feature makes gaseous scintillators highly useful for some applications in the time-of-flight neutron spectrometry. A mixture of Xe and He enriched in He is also a good scintillator. Another table contains the most important properties of several Soviet photomultipliers used in fast counters. These photomultipliers all have a mercury-cesium photocathode with a maximum sensitivity near 4000Å. There are 1 figure and 2 tables.

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21(3)

AUTHORS: Rybakov, B. V., Sidorov, V. A.

TITLE: Chapter VII (Glava VII). The Time Analyzer (Vremennoy analizator)

PERIODICAL: Atomnaya energiya, 1958, Supplement, Nr 6, p 123 (USSR)

ABSTRACT: In recent years a great number of different time analyzers for the range of millimicroseconds have been developed and described. The authors investigate only the main types of time analyzers which can be used in neutron spectrometry. There are 28 references, 7 of which are Soviet.

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